Respiratory muscle training by using incentive spirometer increases the respiratory muscle strength among the post tracheostomy patients after decannulation - A prospective study

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Abstract-

Background of the study:

The diaphragm is the strongest inspiration muscle, the dysfunction of diaphragm is generally observed in tracheostomy patient due to altered Breathing pattern and limited use of respiratory muscle due to Prolonged bed rest. There is also some evidence to suggest that mechanical ventilation may adversely affect diaphragmatic structure and function. These alterations, known as ventilator-induced diaphragmatic dysfunction, involve changes in myofibril length and rapid.The incentive spirometer a device that measures the volume of the air inhaled into the lung's during inspiration is known to have following benefits like improved lung volumes and reduced pulmonary complications. These techniques help in enhanced lung ventilation by increasing the expansion of chest wall, helping maintain or increase appropriate lung volumes and capacities, and eventually reduce the incidence of pulmonary function loss and its eventual complications. Therefore, it aids in the preservation of airway patency by increasing muscle activity through respiratory muscle training techniques. Inspiratory muscle training can generate the inspiratory pressure, which increases the resistance to muscle fatigue, respiratory function, lung volumes and capacities and redistribution of the blood flow to the muscles.

Objectives:

To improve strength of diaphragm in post tracheostomy patients

To evaluate effect of inspiratory muscle training on diaphragmatic strength in post tracheostomy patients

To evaluate effect of inspiratory muscle training on endurance of post tracheostomy patients

To evaluate the MMT of diaphragm pre and post spirometry in post tracheostomy patients

Methodology:133 patients will be randomly selected from post tracheostomy patients admitted in wards. They will be taught incentive spirometry exercises pre discharge and told to follow up from home and will be prescribed incentive spirometry 3 times per day for 15 minutes for 2 months. The MMT of diaphragm will be calculated pre and post spirometry in these patients

Results: Strengthening exercises to diaphragm will improve efficiency of breathing through increased recruitment of diaphragmatic fibres. Post tracheostomy patients have weak respiratory muscles due to disuse. Incorporating diaphragm strengthening in this patients on a OPD basis will help achieve a better outcome with regards to chest expansion, airway clearance, breathing patterns due to increased diaphragmatic recruitment.

Conclusion The study concludes that home exercise program using incentive spirometry has improved the diaphragm strength in post tracheostomy patients.

INTRODUCTION

The diaphragm muscle is the main muscle for breathing, influencing with its contractions the respiratory activity. The diaphragm collaborates to various processes such as expectoration, vomiting, swallowing, urination, and defecation. It facilitates the venous and lymphatic return and helps the viscera above and below the diaphragm to work properly. Diaphragm's activity is fundamental in the maintenance of posture and body position changes.

According to its insertions, the diaphragm can be divided into costal, lumbar, and sternal portions. The sternal part arises with two small fiber bundles from the posterior aspect of the xiphoid process, near to the apex, the costal (or lateral) portion arises from the inner and superior aspect of the last six ribs, with interdigitation with the transverse muscle of the abdomen. The lumbar portions arise from the medial, intermediate, and lateral ligaments of the diaphragm. (1)

Tracheostomy is a method of intubating the trachea, which is employed in several clinical settings. Tracheostomy is believed to facilitate weaning through changes in respiratory mechanics (2)

Diaphragm function is a major determinant of weaning from mechanical ventilation in intensive care unit (ICU) patients and influences the duration of mechanical ventilation. The dysfunction of diaphragm is generally observed in tracheostomy patient due to altered breathing pattern and limited use of respiratory muscle due to prolonged bed rest. There is also some evidence to suggest that mechanical ventilation may adversely affect diaphragmatic structure and function. These alterations, known as ventilator-induced diaphragmatic dysfunction, involve changes in myofibril length and rapid (3)

Diaphragm dysfunction frequently develops in mechanically ventilated intensive care unit (ICU) patients and is associated with adverse clinical outcomes including prolonged mechanical ventilation and mortality. It appears that non-physiological diaphragm activity plays an important role, in which both disuse atrophy resulting from ventilator over-assist and high respiratory muscle effort resulting from ventilator under-assist have been associated with diaphragm dysfunction in ICU patients. Therefore, there is a strong physiological rationale for monitoring diaphragm effort and titrating support to maintain respiratory muscle activity within physiological limits (4)

The incentive spirometer a device that measures the volume of the air inhaled into the lung's during inspiration is known to have following benefits like improved lung volumes and reduced pulmonary complications. When breathing in through an incentive spirometer, a piston rises inside the device and measures the volume of the inspired air. The incentive spirometry device is widely used in physical, speech, and respiratory therapy as it encourages the patient to perform a slow and deep inspiration through visual feedback. Breathing in slowly is important with spirometer use as it allows the lungs to stretch and opens the airways.

The use of the incentive spirometer in inspiratory muscle training has been shown to maintain or increase inhaled lung volume, prevent lung infection after surgery, and improve sputum expectoration. Also, inspiratory muscle training is a vital factor in reducing or preventing postoperative complications.

So, techniques help in enhanced lung ventilation by increasing the expansion of chest wall, helping maintain or increase appropriate lung volumes and capacities, and eventually reduce the incidence of pulmonary function loss and its eventual complications. Therefore, it aids in the preservation of airway patency by increasing muscle activity through respiratory muscle training techniques (5)

Inspiratory muscle training applies a load to the muscles of inspiration, with the goal to oppose the catabolic effects of MV and diaphragm inactivity, thereby improving fibre activation, cross sectional area, and contractile force. Like other peripheral muscles, the diaphragm is susceptible to atrophy and hypertrophy with changes in activation and loading (6)

MMT is a reliable measurement to evaluate respiratory muscles strength of patients with asthma. This assessment can be applied by health professionals during thorax physical examination, widening the analysis of ventilatory mechanics in each case.

It is a useful, practical, low-cost, and easy to perform tool to assess muscle groups differentiating their fibres. When correctly applied, MMT is an efficient procedure within the clinical survey of muscle work, provided that the basic conditions for efficacy of the test are fulfilled; namely, evaluator specific training, adjacent musculature relaxation, posture, adequate hand contacts and standardised verbal commands (7)

OBJECTIVES

Primary objective

To improve strength of diaphragm in post tracheostomy patients

Secondary objective

To evaluate effect of inspiratory muscle training on diaphragmatic strength in post tracheostomy patients

To evaluate effect of inspiratory muscle training on endurance of post tracheostomy patients

To evaluate the MMT of diaphragm pre and post spirometry in post tracheostomy patients

METHODOLOGY

Study place: Narayana health City, Respiratory OPD

Study subjects: 133 post tracheostomy patients.

Study Period: 3 months.

Study design: Prospective.

Sample size: 133 participants.

Sampling technique: simple random sampling

INCLUSIVE CRITERIA

Post tracheostomy patient with respiratory and neuromuscular disorder.

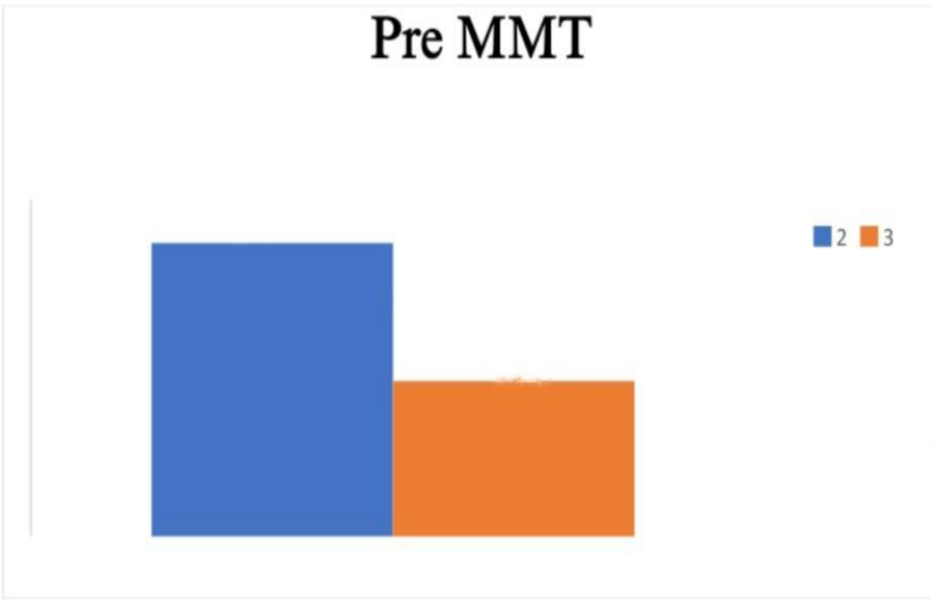
Post tracheostomy patients who were discharged within 3 months from ICU.

EXCLUSION CRITERIA

Patient below 18 years of age
Patients with disorder other than respiratory or neuromuscular disorder like musculoskeletal and psychiatric disorder
Patients discharged from ICU for period longer than three months.
Patients who are unwilling to cooperate
Patient having unstable vital.

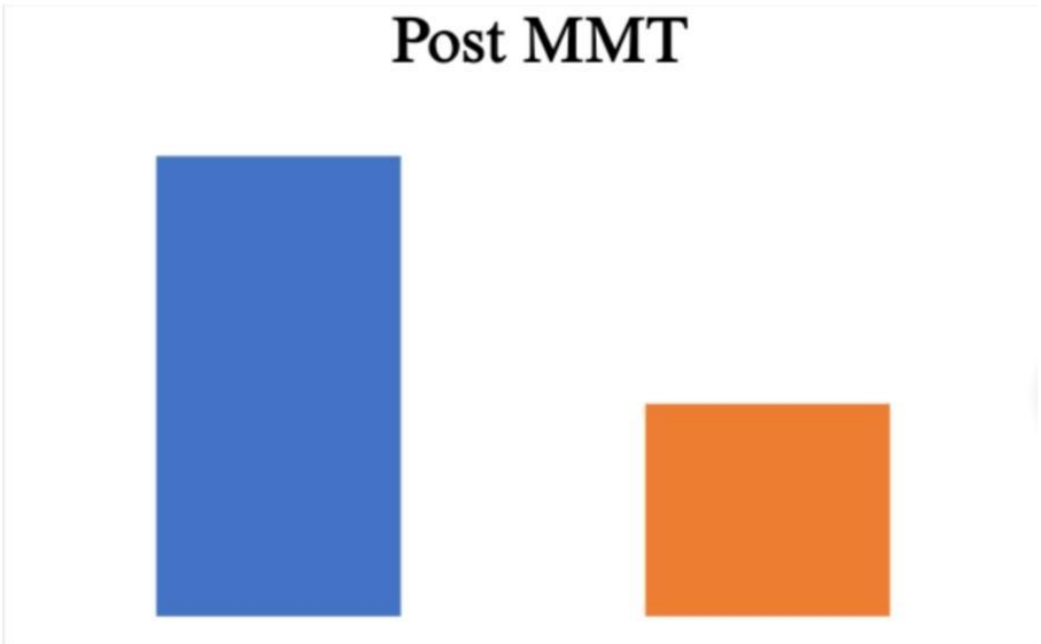
The participants who underwent tracheostomy were taught to use incentive spirometer post decannulation under supervision of physiotherapist. The pre spirometry and post spirometry MMT of diaphragm were analysed and the data were managed by MS word 2007 and analysed by SPSS version 27.Manual muscle testing grading was used as measuring tool which were assessed before and after use of incentive spirometer.

RESULTS



Graph 1: Bar graph for pre-exercise grade

The graph 1 shows the MMT grade of post tracheostomy patients before spirometer was garde 2 in 66 patients and grade 3 in 21 patients



Graph 2: Bar graph for post exercise grade

The graph 2 shows the MMT grade of post tracheostomy patients after using spirometer was grade 3 in 25 patients and grade 4 in 21patients.

Pre and Post Comparison

	2	3	P value
	N (%)		
3	66 (75.9)	25(54.3)	0.011*
4	21(24.1)	21(45.7)	

*Table 1: Statistical Test: Chi-Square Test; P-Value <0.05- Significant**

The above table (table 1) shows that out of 133 post tracheostomy patients,66 patients(79 %) who were on grade 2 of MMT before using incentive spirometer where improved to grade 3 after using incentive spirometer .21(24.1%)patients who were on grade 2 before using incentive spirometer where improved to grade 4 after using incentive spirometer. 21 (45.7%) patients who were in grade 3 before using incentive spirometer where improved to grade 4 after using incentive spirometer.25 (54.3%) patients who were on grade 3 before using incentive spirometer remained in grade 3 even with use of incentive spirometer.

ANALYSIS

MMT of diaphragm was used as the outcome measure for assessing the improvement in the strength of diaphragm before and after the use of spirometry in post tracheostomy patients .

The pre and post spirometry MMT grades were analysed, and the data was managed by word 2007 and analysed by SPSS 27.

There are significant changes in strength of diaphragm in post tracheostomy patients after use of incentive spirometer as 79% patients after using incentive spirometer improved from grade 2 to grade 3 and 24.1%patients after use of incentive spirometer improved from grade 2 to grade 4 and 45.7% patients after using incentive spirometer improved from grade 3 to grade 4 and only 54.3 % patients with initial grade 3 remained same after use of incentive spirometer.

Based on the above results, we can state that:

There was significant difference in MMT grades pre and post spirometer in post tracheostomy patients	*P value - 0.011**

*Table 2: Statistical analysis P-Value <0.05- Significant**

DISCUSSION

One of the most common treatments used in intensive care is invasive mechanical ventilation (MV), either via an intubation tube or a tracheostomy. Under MV, the diaphragm is relaxed. This can cause a specific disorder termed ventilator-induced diaphragmatic dysfunction. The diaphragm atrophies, changes occur in its ultrastructure and contractility is reduced, resulting in a loss of maximal strength(1)

Levine et al. showed that 18–69 hours of controlled MV leads to more than 50 % reduction in the cross-sectional area of type I and II diaphragm fibres [3]. This atrophy is the result of a reduction in protein synthesis and acceleration in protein degeneration. After only 6 hours of ventilator-induced diaphragmatic dysfunction, the synthesis of mixed proteins is reduced by up to 30 % and the synthesis of heavy myosin chains is reduced by up to 65 % (2) This review provides strong evidence that inspiratory muscle training significantly increases inspiratory muscle strength in mechanically ventilated patients via tracheostomy. (3)

Incentive spirometer uses visual feedback to assess a patient's inspiratory effort by measuring the inhalation volume. The incentive spirometer can be used in rehabilitation as a favourable tool, as it is inexpensive and easy to manage with no known side effects. It is simple to train and does not require assistance once a patient has learned how to use it properly. Furthermore, the visual feedback encourages patient compliance.

The use of the incentive spirometer in inspiratory muscle training has been shown to maintain or increase inhaled lung volume, prevent lung infection after surgery, and improve sputum expectoration. Although research on the effectiveness

of incentive spirometry for chronic conditions is mixed, inspiratory muscle training is a vital factor in reducing or preventing postoperative pulmonary complications. Using an incentive spirometer following surgery can help preserve the lungs' integrity and keep the lungs clear. Deep breathing supports the movement of secretions and assists in opening lung spaces that may have become collapsed. Inspiratory muscle training stretches and exercises the lungs, keeping them engaged, especially while recovering from surgery. (4)

In our study we focused on improving the diaphragm strength in post tracheostomy patients by using incentive spirometer and the strength of diaphragm were analysed with the help of MMT grades. The analyses of the data showed that there is significant difference in strength of diaphragm before and after use of incentive spirometer in post tracheostomy patients. Thus, the inspiratory muscle training in these patients has improved strength of diaphragm which prevents further diaphragmatic diffusion and improve ventilation.

The incentive spirometer is non-invasive measure and easy to use equipment for the patient. The use of spirometry is cost effective. It improves the diaphragm strength in post tracheostomy patients as well as the breathing pattern.

CONCLUSION

The study concludes that home exercise program using incentive spirometry has improved the diaphragm strength in post tracheostomy patients.

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CONFLICTS OF INTEREST

The authors do not have any conflict of interest to declare.

ETHICAL APPROVAL

The study was approved by the research committee and a formal permission was obtained from concerned authorities of the hospital and associated departments.No ethical issues arouse during the study.

STATEMENT OF INFORMED CONSENT

Informed consent was obtained during the study. The subjects were informed that the confidentiality of the data was maintained. The subjects were informed that their participation was on voluntary basis and can withdraw from the study at any time.

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